FINER POINTS

1946 60th ANNIVERSARY 2006 INDUSTRIAL DIAMOND ASSOCIATION OF AMERICA, INC.

"The ONLY magazine dedicated solely to the technology and application of superabrasives."

POLYCRYSTALLINE DIAMOND and cBN

WINTER 2008/2009

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2009 IDA Annual Meeting

Cutting Tool Material Requirements for the Airframe Industry

Polycrystalline Diamond (PCD) & Polycrystalline Cubic Boron Nitride (PCBN) Materials – Processing, Applications and Advantages

PCD Engineered for the Demands of High-Speed Milling

Cubic Boron Nitride

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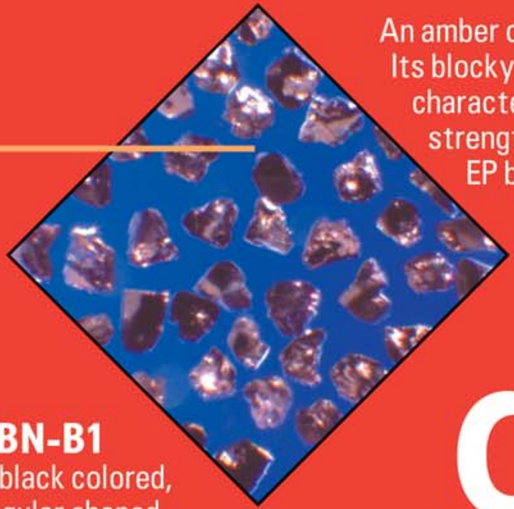
An amber colored blocky shaped crystal. Its blocky shape, consistent fracturing characteristics and superior crystal strength make CBN-A 90 ideal for EP bond systems. Available from 50/60 thru 325/400 mesh.



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"The ONLY magazine dedicated solely to the technology and application of superabrasives."

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COVER PHOTO

Photo courtesy of Boeing Company. Boeing is dedicating use of superabrasives for the intricate and difficult manufacturing demands on superalloys and other high tech composites. Superabrasives improve productivity and reduce manufacturing costs. See article on page 13.

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FINER POINTS is the only publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these "superabrasives", either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

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A Finer Point of View…

There is no immunity from the economic slump that has burdened every company involved in the capitalistic community. The imbalance of rising costs and shrinking volume strengthens this economic turbulence. Everyone touched by the struggling economy is challenged to behave rationally by practicing some basic business principles easily overlooked during these desperate times.

Manufacturers need to rationalize production and better control inventory based on the realities of market demand and what is essential to their customers. The manufacturing of excess and unneeded products forces unnecessary stress on a manufacturer's bottom line. More importantly, with the tightened credit markets, unnecessary inventory consumes one of the more valuable business tools: capital. Identify which products are vital for the health of your business and manufacture accordingly.

Each employee at every company can likely come up with a creative way to trim unnecessary costs. Using scrap paper, shutting off the office lights at night and replacing paper towels with automatic hand dryers are all sensible options for cutting routine costs. Ask employees where they see unnecessary spending. Their suggestions may be as simple as eliminating complimentary coffee or as profound as cutting an unprofitable product line that has little or no growth potential and consumes cash. As long as trimming these expenses does not negatively affect profitable business practices, cost savings will help ease the clutches of this bear market economy.

Do not mortgage your company's future by cutting too deep or too widely. Intelligent cost-cutting choices will eliminate unnecessary costs and salvage costs, which are imperative to a company's long-term health. For example, research and development is essential in the world of manufacturing to prevent commoditization, meet specific end-user demands and ensure efficiency. It is costly but imperative for growth and should not be sacrificed for short-term cost savings. Likewise, any activity that risks sacrificing quality in the name of costs, while potentially helpful in the short term, can have devastating effects in the long term.

It is an ugly fact that costs are going up and volume is going down. Offering value should never be compromised as a result of rough economic circumstances. Customers understand the results of economic hardships but will not tolerate diminished value or lack of productivity in response. Do not jeopardize customer relationships and your company's reputation by eliminating value from the sales package, as value can continue to be sold and appreciated even more when cost pressures are the highest. When customers part with their money during recessionary periods, the importance of value is more evident. Carry the value message to your customers and suppliers and vigilantly debunk the "low initial-purchase-price is better" myth.

PRESIDENT
Martin Deakins

Concentrate on your most profitable business segments, not necessarily the largest. Selling unprofitable volume tends to be diversionary, making the top line look good, but contributing very little to the bottom line of a business. A more drastic measure of staying afloat in a rough economy is to purge high cost-to-serve customers whose demands consume a disproportionate share of corporate assets. Who are these customers? They are: customers who have bad credit, customers who nickel and dime you on unprofitable volume, customers who use your technical resources and then "bid out" the volume after joint development is complete. The combination of profitable volume and valuable customers is an overlap worthy of your dedication.

A basic principle of business is to manage cash closely at all times. As much as we have to pay attention to our own ledger, we have to stay abreast of the health of our customer's financial state too. We should never be blindsided by the bankruptcy of a customer if we are aware of their payment history and general financial health.

The economic ebb and flows are inevitable. Smart businesses that make rational decisions can withstand the grips of a bad economy and coast swiftly during a good economy. We were witnesses to the Great Depression in the 1930s and the recession of the 1980s when spending was at a halt and unemployment peaked above 10%. Sound businesses are created to withstand such periods by having long-term goals, visions and plans that enable their survival. One of the most respected and successful entrepreneurs of all time, John D. Rockefeller, said, "these are the days when many are discouraged. In the 93 years of my life, depressions have come and gone. Prosperity has always returned and will again." Economic turmoil is certain.

Do not panic. Behave smartly,

Martin Deakins

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Editorial

A MAGNIFICENT OBSESSION

This past fall I was invited to present a paper on the global superabrasives market at the 5th ZISC in China. This was one of the most eye-opening experiences I have ever had in all my years in this industry. Using published data from many resources including import and export reports from the the U.S. Census Bureau, major industry publications and surveys from leading companies and organizations around the world, I came to realize no one really has definitive numbers on global superabrasive production levels. Most were missing major sections of data and others were caught in a loop of obtaining information from sources feeding them back their own data! This trend is unaffectionately called "drinking your own bath water". Other well-intentioned individuals do not report any data or they give fictitious numbers to slant industry reports. I must point out; the "liar liar pants on fire" ridicule still won't get them to cooperate! Undaunted I surged forward to come up with the most accurate numbers.

TERRY KANE, Editor

When I finalized my paper, I felt extremely positive of my facts. I knew where I had looked, who gave me the numbers and then I passed the data back and forth between numerous industry experts for review… my confidence level was high!

Arriving in China I was made to feel a welcome that was one of true friendship from the many dignitaries and attendees to the 5th ZISC. I was treated to plant tours of some major Chinese manufacturers and spoke with many more about their facilities and capacities. I found them all to be proud of their accomplishments and willing to share details of their operations.

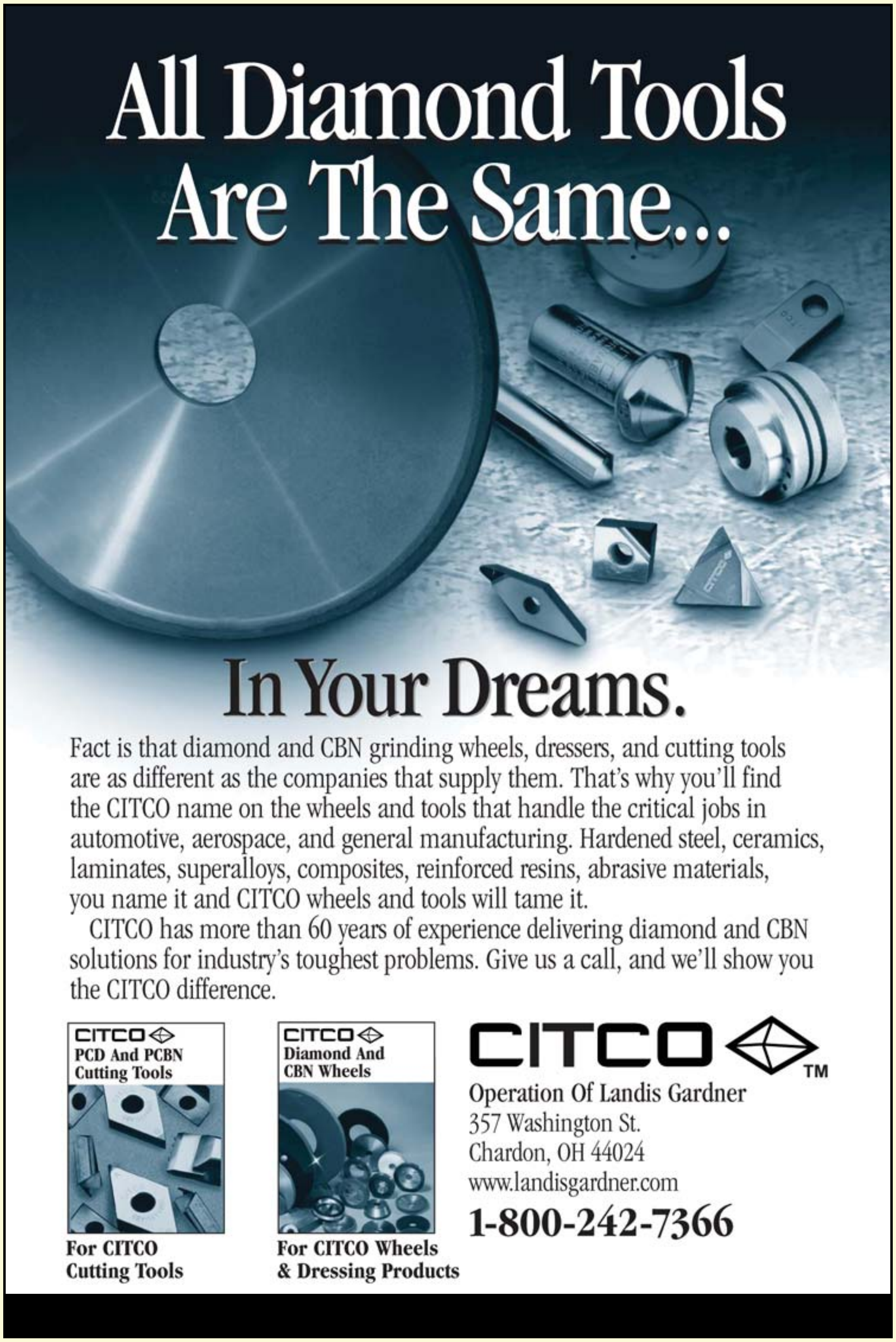
The 5th ZISC hosted many leaders from our industry and the presentations were both interesting and informative. However, my confidence level in the data I acquired on the global production numbers slowly ebbed as I listened to presentations by my peers from around the world. Their numbers varied greatly from each other, with the data of all presenters being uniform in its inconsistency and exponentially different in summation. I believe there is a disparity (language barriers?) between what presenters were reporting as capacity versus actual saleable production.

As a follow up to the 5th ZISC I now have very good resources and personal global contacts to reevaluate all the data points and provide the best production numbers for the world's superabrasive markets.

What started as a simple fact finding effort has now become a magnificent obsession… Forget finding the Holy Grail, The Ark of the Covenant, Amelia Earhart's plane or the secrets of The Da Vinci Code, Roswell and what's at Area 51. The real venture into the unknown is determining what the actual production numbers are for the global superabrasives industry! Pick any country, industry report or organization and you get a relatively close yearly estimate somewhere between 1 and 10 billion carats! Whether this includes all mesh products of diamond types, cbn, micron or feedstock is anyone's guess… excuse me, estimate.

Stay tuned… within the next couple of months, hopefully by the IDA Annual Meeting in March; I will finish my quest for that elusive answer regarding global production numbers for superabrasives.

Now… about that Area 51…



Fact is that diamond and CBN grinding wheels, dressers, and cutting tools are as different as the companies that supply them. That's why you'll find the CITCO name on the wheels and tools that handle the critical jobs in automotive, aerospace, and general manufacturing. Hardened steel, ceramics, laminates, superalloys, composites, reinforced resins, abrasive materials, you name it and CITCO wheels and tools will tame it.

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Industrial Diamond Association of America

2009 Annual Meeting HOLD THE DATES – March 11-13, 2009

View amenities at The Colony www.colonybeachresort.com.
Special IDA room rates of $249.00 per night is being offered for the 63rd Annual Meeting.

It is time to make plans for the 63rd Industrial Diamond Association's Annual Meeting. Arrangements are well underway and we will have significant speakers to address both the economy and industry issues. Programs are in motion to improve your Association and assist all members in education and literature development. Now, more than ever it is paramount for ALL Members to make ever effort to attend. Together we are a powerful force and your voice is needed to guide us all through these challenging times.

In 2002 the Industrial Diamond Association of America had their 56th Annual Meeting at The Colony Beach & Tennis Resort in Longboat Key, Florida. It was so well received that our membership has asked that we return in 2009. The Colony Beach & Tennis Resort is located on exclusive Longboat Key, Florida, a tropical beachfront resort just off the coast of Sarasota that offers both couples and families the perfect island getaway with spacious all-suite accommodations. The Colony is recognized as the No. 1 Tennis Resort in the U.S. for eight consecutive years, the resort's combination of world-class dining, exclusive beaches, complimentary yearround children's recreation programs, full service spa and salon and comprehensive fitness center create The Colony's unique character.

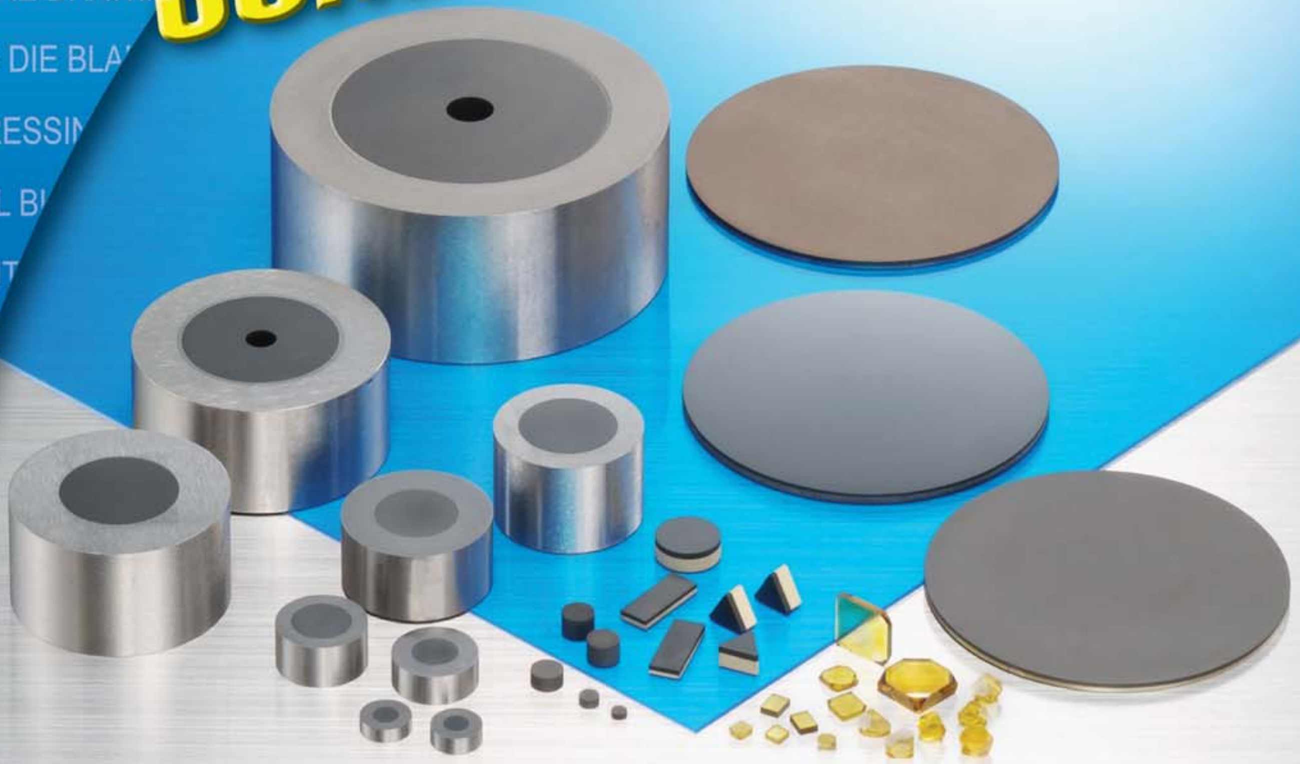
The Colony has the ultimate atmosphere for meetings with complimentary amenities that include:

- TENNIS ON 21 COURTS (10 ARE SOFT HYDRO COURTS)
- ROUND ROBINS & GUARANTEED MATCH MAKING SERVICE
- A STATE-OF-THE-ART FITNESS CENTER
- FULL-SERVICE HEALTH SPAS WITH WHIRLPOOL, SAUNA & STEAM
- CHAISE LOUNGES & TOWELS
- A BEACHSIDE FRESHWATER SWIMMING POOL
- CONVENIENT PARKING

The Colony Beach & Tennis Resort, has 208 handsomely appointed, fully equipped villa suites and 26 "specialty accommodations" ranging from charming cottages, directly on the beach, to glamorous duplex penthouses. In addition to 21 tennis courts, a beachside swimming pool and a watersports center on The Colony's 800-foot private white-sand beach, guests also enjoy a comprehensive aerobic and fitness center, men's and women's health spas and dining in either of two award-winning waterfront restaurants or on the poolside patio.

A staff of more than 300 is dedicated to making every guest's stay complete perfection. Hold the dates March 11-13, 2009 and watch for more details as plans are finalized!

THE BRILLIANCE OF SUMITOMO DIAMOND



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NEWS and notes

AUTOMAKERS HAVE A DEAL – *Millions of workers sweat the details. A "managed bankruptcy" was proposed as an option for preventing the collapse of Detroit's troubled automobile companies.*

Instead, GM and Chrysler signed deals with the U.S. Treasury to receive $17.4 billion in emergency loans and no bankruptcy will be required. The White House came to the aid of the auto industry but pointed out they would have to go through a managed restructuring to become viable, self-sustaining businesses. Many still think that bankruptcy may well be the ultimate fate of Detroit's automakers unless they use the White House's three-month, $17.4-billion loan to reinvent themselves along the lines of the conditions demanded in the loan deal.

SP3 DIAMOND TECHNOLOGIES, INC. (SP3) ANNOUNCES INDUSTRY VETERAN WILLIAM PEIFER AS ITS DIRECTOR OF SALES.

– Peifer, is tasked with actively pursuing increased sales of the company's CVD diamond products for thermal management applications and wafer scale diamond, as well as supporting existing sales efforts for sp3's non-thermal related applications. Peifer will also be responsible for accelerating the expansion of sp3's sales organization, primarily through the addition of representative organizations across the U.S. "Bill comes to sp3 with broad experience in moving various novel technologies to adoption in real-world applications," said Dwain Aidala, president and COO of sp3 Diamond Technologies.

CINETIC LANDIS CORP. DEDICATES NEW, STATE-OF-THE-ART HEADQUARTERS – *Hagerstown, Maryland* –

Cinetic Landis Corp. has officially dedicated its new headquarters and manufacturing facility located in Hagerstown , Maryland. Approximately 250 employees, company executives and guests from local academia and government agencies recently convened to mark the official opening of the new the new home of Cinetic Landis Corp. The firm is recognized as a leader in the design and manufacture of precision grinding machines and systems that manufacturers worldwide depend on for producing precision components. Cinetic Landis president and CEO, Daniel Pheil, introduced the new 108,700 sq. ft. facility as a sustainable, green foundation for the company's next century of progress. More information about Cinetic Landis Corp. is available on the company's website at www.fivesgroup.com/landis

TYROLIT, INC. ANNOUNCES THAT DAVID DIEDRICH HAS BEEN HIRED AS SUPERABRASIVE KEY ACCOUNT SALES MANAGER OF THE NORTH AMERICAN DIVISION.

– David brings 20 years of technical sales and management experience in the abrasive industry with most of his knowledge concentrated in Superabrasives. Most recently, he held a position with the National Research Company as Sales & Marketing Manager. David has held positions with globally recognized companies within the industry including both General Electric and the Norton Company. David will be focused on defining and developing strong, long lasting, mutually beneficial relationships with key Superabrasive Accounts in the U.S. FOR MORE INFORMATION CONTACT: Jason Melcher Jason.Melcher@tyrolit.com Vice-President of Marketing, North America

VOLLMER SHOWCASES NEWEST PCD TECHNOLOGY WITH DEMONSTRATIONS OF THE QXD200 MACHINE AT THEIR US HEADQUARTERS IN CARNEGIE, PENNSYLVANIA.

– Customers that had expressed an interest in seeing the QXD200 were invited to bring their own tools for machining demonstrations using the 6 axes programming, with erosion and grinding of the PCD surface. These demonstrations featured Arndt Hauger, the PCD product manager from Germany, who along with others from VOLLMER Werke was instrumental in bringing this new technology to the industry. Many of the improvements incorporated on the machine were the result of customer requests for improvements needed in finishing a multitude of PCD tools. In addition to toolmakers, the PCD suppliers were also invited to bring their latest products for testing and parameter optimization on the QWD760 wire erosion machines. This provided an opportunity for the application personnel from these organizations to better understand the VOLLMER technology and be better prepared to assist the tool fabricator and end user of the PCD materials. Werner Lueken, from Zoller, was also present to aid in measuring the finished tools and evaluating the PCD surface finish. For further information: www.vollmerus.com.

ABRASIVE TECHNOLOGY HAS ANNOUNCED THE DEVELOPMENT OF A WORLD-CLASS LEARNING CENTER.

– The 8,000-square-foot facility, housed at the Company's world headquarters in Lewis Center, Ohio, USA, is an extension of the company's focus on developing a "Learning Culture". The Center will house educational, meeting and fitness areas; and will also be the home to Abrasive Technology's Learning Culture Communities of Practice (CoP). Key components of the Learning Center include an auditorium/classroom space that can accommodate training and development gatherings of up to 250 associates. The space will include movable walls and state-of-the-art audio visual amenities. There is also a library that will house both print and web-based learning materials. Abrasive Technology is a globally integrated leader dedicated to developing, manufacturing and marketing superabrasive grinding wheels and tools for a wide variety of medical, dental, electronics, industrial, aerospace, lapidary, optical and consumer applications. For further information contact: www.abrasive-tech.com

RHENIUM DIBORIDE, AN ULTRA-INCOMPRESSIBLE, SUPERHARD MATERIAL

Scientists at UCLA have manufactured the superhard material, rhenium diboride (ReB2), at ambient pressures as a substitute for diamond and other superhard materials currently used in industry. Because of the high cost of diamond and diamond-substitutes for use as cutting and polishing tools and wear resistant coatings, scientists have long studied how to manufacture hard and superhard materials as replacements for these materials. Diamond gathers much of its strength characteristics from its atomic configuration and molecular bonding scheme. Diamond is a versatile abrasive and cutting tool however; it is very expensive and is ineffective when dealing with ferrous materials because of the formation of carbides during the cutting process. Diamond-substitutes, such as cubic boron nitride, are attractive alternatives that do not have this issue with ferrous materials, but their synthesis requires costly high-pressure manufacturing techniques. To overcome many of these problems with materials in this area, researchers at UCLA have identified a way to manufacture a superhard material, rhenium diboride (ReB2), at ambient pressures. They have shown this material possesses incompressibility along its c-axis similar to that of diamond, has a high differential stress, and has high hardness under low load similar to cubic boron nitride.

SP3 DIAMOND TECHNOLOGIES INTRODUCES NEW CVD DIAMOND DEPOSITION SYSTEM FOR DOPED DIAMOND APPLICATIONS

SANTA CLARA, CA – sp3 Diamond Technologies, Inc, a leading supplier of diamond film products, equipment and services, today brought to market the newest member of its Model 650 Series of Hot Filament CVD (chemical vapor deposition) Diamond Coating Systems with the Model 655D for doped diamond applications. The Model 655D incorporates advanced process capabilities to dope diamond as it is deposited, making it electrically conductive with resistivity from .05 to 10 ohm-cm, while maintaining excellent uniformity. The Model 655D also integrates new system controls and a dedicated user interface to assure process repeatability and intrinsically safe operation. sp3's hot filament diamond deposition technology offers customers a critical advantage in terms of reduced development time and shortened timeto- market. By incorporating electrically conductive diamond into its reactor's broad range of commercial applications, which includes cutting tools, wear surfaces and wafer-scale diamond, sp3 is expanding future customers' opportunities to implement thin film diamond in conductive diamond applications, such as in coated electrodes for water treatment and electrochemistry. **For more information about the company and its products and services please visit www.sp3diamondtech.com.**

LACH DIAMOND, A PIONEER AMONG THE MANUFACTURERS OF DIAMOND TOOLS ANNOUNCES PATENTED PCD INSERTS WITH CHIPBREAKERS.

Since more and more aluminum has been applied in the automobile and aircraft industry for weight savings, the application of forging alloys is advancing, however, with certain disadvantages at cutting. In comparison to conventional aluminum alloys, these significantly tougher alloys tend to produce unwanted ribbon chips and thread chips. By unforeseen and Turning without chipbreaker unwanted machine shutdowns tools can be damaged which have to be replaced and in some cases large clews of cutting chips have to be removed from the working space of these machines. The chipbreaker by LACH DIAMOND enables an efficient and trouble-free production and guarantees controlled chipbreaking of long chip aluminum alloys. **Further information can be obtained from LACH DIAMANT at www.lach-diamond.com**

Turning without Chipbreaker

Turning with LACH PCD Chipbreaker

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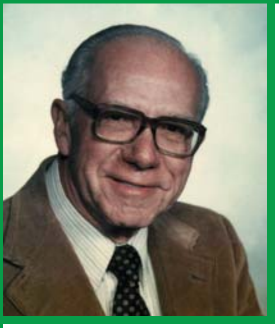
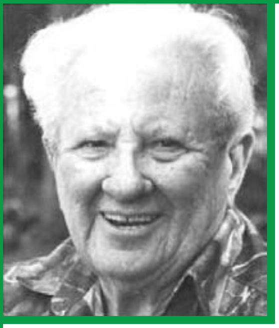
In MEMORIAM

The Industrial Diamond Association recently lost two significant contributors to the growth and prosperity of the Diamond Industry. Art Redebaugh and Sherwood Florian will be missed greatly by all their friends and colleagues. It is times like these we fondly remember our predecessors.



G. Arthur Redebaugh

Art Redebaugh passed away December 1, 2008. Art graduated from the University of Illinois in 1936, with a B.A. degree. After college, his first business position was with Marshall Field & Co. in Chicago, where he became an Assistant Manager. Art and his wife of 68 years, Virginia met in 1940 and married in Chicago but he left for Detroit in early 1941 where he joined the Koebel Diamond Tool Co, manufacturers of diamond dressing tools and mining and prospecting bits. In 1946 he became General Manager and then Executive Vice-President in 1961. Upon acquisition of the company by the Norton Company in 1969, he continued as General Manager until his retirement in 1976. Art continued with the Norton Company as a consultant for another 7 years. During that period he also served as consultant to the General Services Administration, the U.S. agency responsible for the stockpile of industrial diamonds. His unique business experiences included an all-day observance of diamond drilling while 3200 feet underground in a gold mine in northern Canada, and a similar time watching diamonds being mined at 2500 feet under-ground at the Kimberley mine in South Africa. Art was a charter member, Past President, and Honorary Life Member of the Industrial Diamond Association of America and was often called upon to address groups on the subject of industrial diamonds, and their uses. Art and Virginia have 2 sons and 4 grandchildren.



Sherwood L. "Woody" Florian

Sherwood Florian, 88, peacefully passed away the early morning of Tuesday, December 16 2008 following a brief illness. A devoted family man, Sherwood and his wife Nancy had two sons and a daughter. He was an ever optimistic "people person". He was an early achiever, starting with a large early morning newspaper route. During high school he worked as a private chauffeur and later worked several months on a WPA project in Lubec, ME. He also worked in the personnel department of Colt's (Firearms) Manufacturing Co. in Hartford. Sherwood graduated from business school and during World War II served in the Army Air Corps in North Africa. Following the war, Sherwood founded a leather goods business, which he sold, and became sales manager for a building products company. In the 1950's, he was cofounder of the Amplex Corporation, a manufacturer of industrial diamond products, which was initially located in offices above the former Central Theater in West Hartford. In the early years of that company, Sherwood's specialty was to make the diamond tool products and market them nationwide. Over a 20-year span, he served as company vice president, president and then chairman. As the company grew, he supervised a marketing and manufacturing operation serving clients internationally. He developed new products, authored many technical articles, was a public speaker and was listed in "Who's Who in Commerce and Industry" plus other editions of that series.

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CUTTING TOOL MATERIAL REQUIREMENTS FOR THE AIRFRAME INDUSTRY

By: Jeff Lantrip - Commercial Airplanes, The Boeing Company

> ***The airframe industry has been undergoing a major change with the increased use of composites in structural applications. This drives the increased use of polycrystalline diamond, CVD diamond coating, and other superhard cutting tool products. However, along with the increased use of composites, there is also an increased use of titanium, and the need to drill holes in stacks containing both materials. This is a very challenging application that requires a cutting tool material that is both very hard and tough. This article will outline the requirements for new cutting tool materials for the airframe industry.***

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Changes in the Airframe Industry

In order to increase the efficiency of aircraft and reduce the life cycle costs, there has been an increased use of composites and titanium (see Figures 1 and 2).

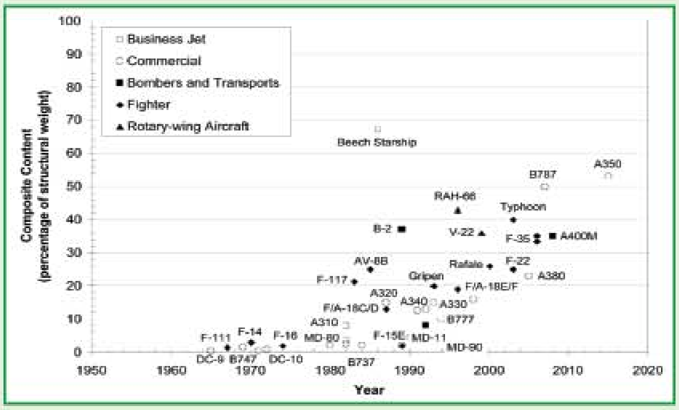


FIGURE 1.

Change in Composite Use in Aircraft

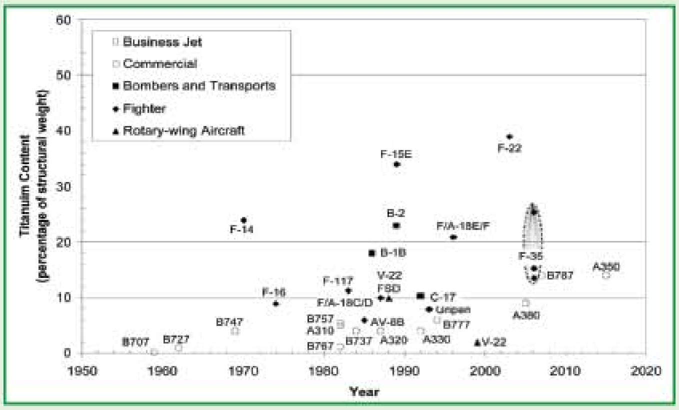


FIGURE 2.

Change in Titanium Use in Aircraft

The Boeing 787 and the Airbus A350 airframes will be mostly composite, as well as Hawker Beechcraft's Premier IA and Hawker 4000 (all-composite fuselages), and Eviation's EV-20 Vantage (all composite fuselage and wings) in the business jet field. The use of composites facilitates part consolidation and bonding, reducing the number of fasteners. However the majority of fasteners eliminated are those termed "acreage fasteners," large numbers of smaller diameter fasteners that lend themselves to automation. Most of the holes that are left are more difficult holes; larger diameter holes in thicker, multiple material stacks. Since there is a galvanic corrosion issue with contact between graphite composites and aluminum, the structural components attached to graphite composites are generally titanium. These two materials are difficult to drill by themselves, and even more difficult when drilled together in a stack. They have different cutting requirements, not only different drilling parameters, but different requirements for a cutting tool material.

Carbon Fiber Composites Machining Challenges

- Material is Very Abrasive – results in high wear rates
- Anisotropic Properties (due to combination of soft matrix and hard fibers in varying orientations) – thus cutting tool sees varying cutting resistance
- Plastic Matrix – limits cutting temperature
- Fiber Reinforcement – requires sharp cutting edge, high shear geometry and high velocity to be cut cleanly
- Laminate Structure – prone to delamination under excessive cutting forces (e.g., high drilling thrust)
- Dust is Created Instead of Chips – requiring vacuum or flood coolant to control

Titanium Machining Challenges

- Low elastic modulus – material pushes away during cutting and "springs back", thus high clearance angles are required
- Low thermal conductivity – leads to high cutting temperatures (80% of heat generated goes into the tool, compared with 50% for steel)
- High chemically reactivity at higher temperatures – has a tendency to weld to the tool, leading to chipping and tool failure
- Work hardening – especially at very low feed rates

- High strength maintained at elevated temperature
- Segmented chip – creates cyclic forces and fatigue on tool
- Greater susceptibility to surface damage during machining operations – resulting in appreciably lower fatigue life

In addition to the challenge of drilling these dissimilar materials together, the following challenges arise in current aircraft assembly which drives increased performance and quality requirements from drilling process:

- The need to drill larger diameters and stacks thicker than previously seen
- Increased drive for one-shot drilling, dry or minimum quantity lubrication (MQL) drilling, and one-up assembly to reduce assembly time
- Although there is increased use of both large- and small-scale automation, pneumatic drill motors are still primarily used in final assembly operations.
- Increased use of lean principles (e.g., moving line, reduced waste)

These items all result in reduced tool life, to the degree that a new cutting tool material is needed to improve cost and productivity. Another thing that drives the need for longer tool life is decreased flow time in final assembly. For the 787, the goal is a 3-day flow in final assembly, and the goal for the F-35 is to product one plane per day out of final assembly. For comparison, the 737 is at a 10 day flow (down from 22 days in 2000, with a goal of 8 days) and the 777 is at a 25 day flow. Part of the ability to achieve that rate on the 787 is due to pushing some of the work upstream, so the pieces arrive prestuffed with aircraft systems, etc., but as noted before, drilling to be done in final assembly is the most challenging.

Ideal Cutting Tool Material

In general, the desirable properties for a cutting tool material are:

- Small grain size to be able to produce a sharp cutting edge
- High hardness, including high hot hardness, to provide excellent abrasive wear resistance
- Good toughness (high TRS & fracture toughness) to maintain sharp cutting edge without chipping/deformation under the dynamic action of the cutting force
- Good thermal conductivity to remove heat from cutting zone
- Thermal stability to maintain integrity under cutting temperatures
- Low chemical affinity or reactivity to workpiece material

The degree to which each of these properties is needed depends on the workpiece material. The difficulty is finding all of these properties in the same material. Generally there is a tradeoff between hardness and toughness (see Figure 3), but for the combination of CFRP and titanium, both are needed.

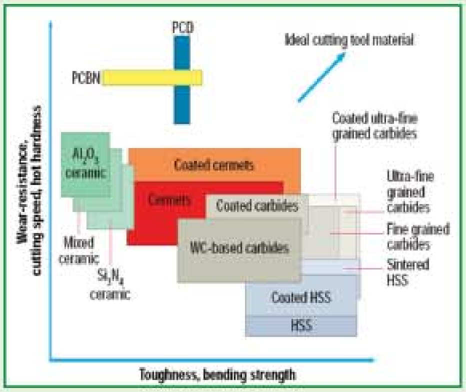


FIGURE 3.
Hardness-Toughness Relationship for Cutting Tool Materials

Polycrystalline Diamond Shows Promising Results

For fiber-reinforced composites such as CFRP, drilling is very much similar to drilling wood. Cutting the fibers cleanly is key, especially at the exit, requiring high shear geometry and high cutting speeds. CFRP is also highly abrasive, so a very hard cutting tool material is required; meaning at least carbide, but preferably diamond. Titanium also likes high shear geometry, but at the higher cutting speeds for composites too much heat is generated, resulting in reduced fatigue life of the aircraft component. In addition, titanium has chemical affinity to most cutting tool materials. Thus, for the most part, cobalt high-speed steel and carbide have been the primary cutting tool materials used for titanium. However, these materials do not have the wear resistance to provide extended life in composites. When the cutting edge dulled by the abrasive composites tries to cut the titanium, workhardening occurs, and then tool failure. There have been some promising results machining titanium with polycrystalline diamond (PCD), but greater toughness is desired to resist chipping. Also, in addition to composite and titanium, there may be aluminum or stainless steel in the stack, each of which has their own requirements.

Areas For Improvement

The chart below shows the improvement in material removal rate for roughing and finishing titanium over time as machining technology improved.

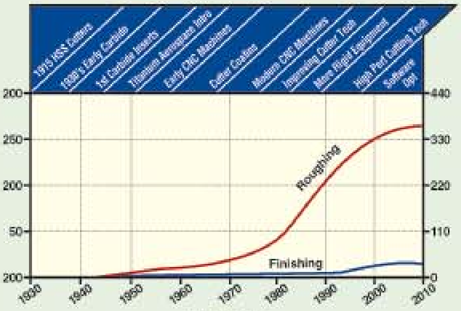


FIGURE 4.
Improvements in Titanium Machining

New Technology in Cutting Tools Needed For Improvement

One can see that the titanium machining improvement has leveled out and there is a need for new technology to enable further improvement, improvement which is much needed considering the substantial increase in titanium in aircraft structure, as well as increased use of composites.

Following are some areas where improvements might be made in cutting tool materials for drilling composite/metal stacks:

- Harder, tougher grades
- Functionally gradient material (to tailor properties to different areas on a tool)
- Nanotechnology (nanograin, nanostructure, etc.)
- Different composition (e.g., non-cobalt binder)
- Self-lubricating capability (to enable dry or near-dry machining)
- Lower material cost
- Lower tool manufacturing and refurbishing cost
- Improved attachment methods

Cutting Tool Material Development Cycle

Once a material having suitable properties has been identified, several other things must be considered in order for it to be a viable cutting tool material for production use. One can view the development of a cutting tool material as following these basic steps:

1. Concept Development

- Synthesis of material envisioned in theory
- Verification of properties

2. Trial use in cutting tools – selected cutting tools made from material and tested

- Inserts
- Round tools

3. Establishment of applicability of material

- Types of tools
- Workpiece materials
- Speed and feed range

4. Commercialization

- Volume production in a cost-effective manner
- Education of sales force to promote product

The timeframe for this process can be quite lengthy, especially if the technical issues are difficult to solve, as shown in *Figure 5* for superhard coatings.

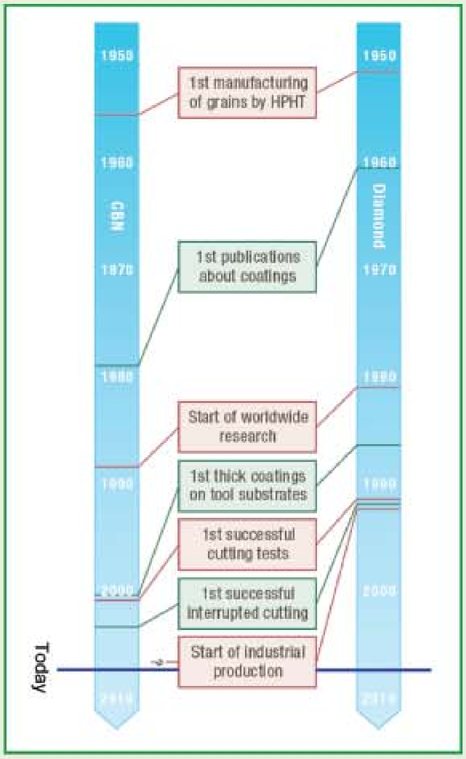

1950
1960
1970
1980
1990
2000
2010
CBN
Diamond
1st manufacturing of grains by HPHT
1st publications about coatings
Start of worldwide research
1st thick coatings on tool substrates
1st successful cutting tests
1st successful interrupted cutting
Start of industrial production
Today

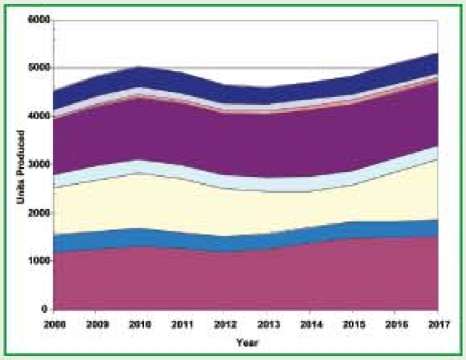
FIGURE 5.
Chronology of Superhard Cutting Tool Coatings

A Market With Tremendous Potential

One can see that there may be many impediments in this process, so connecting the supplier with the right application for the cutting tool material is the key for successful commercialization. So the next question is, "Is the market large enough to make it worthwhile?"

How Large is the Market?

The forecast for the next 10 years is that there will be a general increase in aircraft production; both commercial and military (*see Figure 6*).



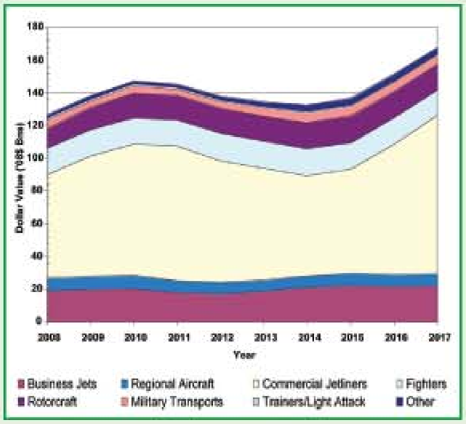


FIGURE 6.
World Aircraft Forecast (Source: Teal Group)

The following shows the number of aircraft that need to be built over the next several years, based on current orders:

Commercial:

- 2007 deliveries: Boeing – 441 ($29.5 billion), Airbus – 453 ($23.9 billion)
- 2007 orders: Boeing – 1413, Airbus – 1341
- Backlog of orders (as of Dec. 2007): >6,800 airplanes (Boeing - 3,427 and Airbus - 3,421)
    - 787: 857 planes on order as of Feb. 2008 – peak production rate of at least 10/mo.
    - A350: 370 planes on order as of Feb. 2008 – peak production rate of 13/mo.
- Current Market Outlook (2007-2026): 22,700-28,600, worth $2.6-2.8 trillion
    - Freighters: 1980 (as of 2006); expect about 4000 (870 new) by 2026
    - Regional jets: currently 2886 (as of Dec. 2006); expect about 3700 by 2026

Military:

- F/A-18E/F: projected 581 fighters through 2012 (US Navy; about $57 million each) – peak production rate of 48/yr
- F-22: ordered 183 fighters through 2010 (US only; about $150 million each) – peak production rate of 32/yr
- Eurofighter Typhoon: projected >700 fighters through 2016 (about $51-58 million each) – peak production rate of 52/yr)
- F-35: projected 3173 fighters through 2035 (about $50 million each) – peak production rate of 48/yr

Examples of Savings Obtained Through Improved Cutting Tools

Example 1:

A fiber-reinforced composites parts supplier for commercial aircraft was only able to drill 150 to 200 holes in 0.200" thick material with a brad-point solid carbide drill before the drill had to be replaced due to unacceptable fiber breakout. With a new CVD diamond-coated carbide drill from a major cutting tool company, the supplier was able to drill up to 2200 holes. Even though the cost of the new drill was 15 times that of the old drill, the cost per hole was 1/5th due to the longer tool life and increased machine time due to much fewer tool changes it provided.

Example 2:

Lockheed was getting less-than-desirable tool life and edge quality when trimming composite wing skins for the F-35. A new CVD diamond-coated cutting tool was developed which increased the tool life from 9 linear feet at one-third the material thickness to 57 linear feet at full material thickness. This allowed machining of a wing skin with two tools instead of 24, resulting in a cost benefit of $80,000 per aircraft, and estimated savings/cost avoidance of $222.6M over the projected F-35 build of 2783 aircraft.

Example 3:

The upper deck floor beams for the A380 are made of CFRP and are attached to aluminum frames on the fuselage. The original uncoated solid carbide drills used for drilling this CFRP/Al stack lasted only 90 holes. Switching to a diamond-coated carbide drill provided over 500 holes per drill.

As a hypothetical example, assume one had an application where there were 90 holes of a particular size in a composite/titanium stack. If one had a drill that cost $150 and it only lasted 20-30 holes, there would be extra time spent changing the drill 3-5 times during the application, as well as possibly needing some extra motors with the drills set up in them so production could continue to flow. If one had a drill that lasted at least 100 holes, even if it cost twice as much (or more), once can see that there could be definite savings in the cost per hole, as well as in flow time. ■

CONCLUSION

Considering the number of aircraft that need to be built using an increased amount of composites and titanium (as well as superalloys, ceramics, high silica aluminum and other materials) and the push for reduced assembly flow time, the opportunities for improvement are great, and thus the opportunities for cutting tool companies and superabrasive suppliers of industrial diamond, cubic boron nitride, CVD diamond, polycrystalline diamond, polycrystalline cbn and related superabrasives to provide improved products is just as great and the aircraft industry is waiting for a response to meet the challenge.

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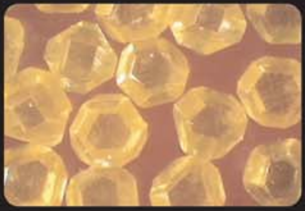

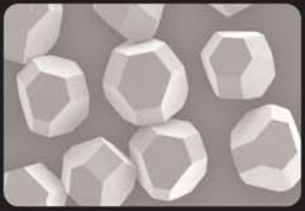

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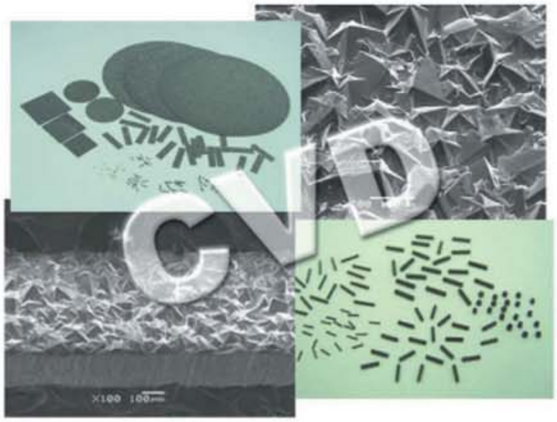

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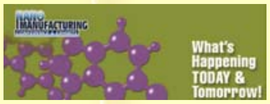

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POLYCRYSTALLINE DIAMOND (PCD) AND POLYCRYSTALLINE CUBIC BORON NITRIDE (PCBN) MATERIALS – PROCESSING, APPLICATIONS AND ADVANTAGES

By: Scott Ries, PCD Division Manager – Vollmer of America

POLYCRYSTALLINE DIAMOND (PCD) BASICS

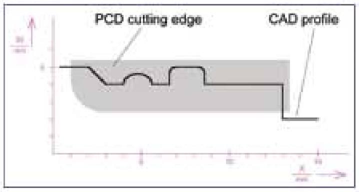
Polycrystalline diamond as we know it today, had its commercial origin over 30 years ago, and yet there still remains a great deal of questions on how to optimize its use. When PCD is discussed, it generally includes PCBN as well as PCD. PCD, in its truest sense is a carbon based element and does not work as well in machining of ferrous-based materials. PCBN, or cubic born nitride is better suited for the ferrous materials due to its non-carbon structure. The use of cutting tools fabricated from these superabrasive materials has helped create tremendous advances in the technology of alloys and composites used in the aerospace, automotive and many other industries. When used properly they provide increased productivity, tighter tolerances and reduced operating costs.

PCD PROCESSING FROM BLANKS - HISTORY

PCD & PCBN blanks produced today have improved greatly since their introduction in the 1970s. The first PCD & PCBN blanks designated for cutting into tipped tools were finished to 13.1mm, which is slightly smaller than a dime. At that time, there was only one grade of PCBN. PCBN designated for use as inserts were finished to a diameter of 19mm so that a BSNU43 could be produced by grinding the edges flat. This early PCD & PCBN posed several other problems.

Although the PCD was conductive, the wire EDM machines were not capable of creating the intricate designs that we rely on today. Programming was done by hand and entered into the machines keyboard. Computer storage was limited in most models and many machines ran off of programs that used G/M codes created by punching holes into paper and Mylar tapes that were fed into the machines "tape reader". The machines were also not capable of creating cutting edges that could be used in finished applications as early power supplies were DC voltage and utilized capacitors instead of the square wave generators in use today, creating a very rough surface. These machines were also limited to 2-axis movement. Cutting speed on these early machines was 1.0–1.5 inches per hour for a 3.2mm thick piece. As a result, the vast majority of cut pieces were simply segments or pie shapes later brazed on to tool bodies and ground for use in metalworking, primarily turning applications.

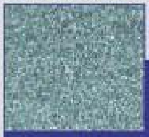
PCBN on the other hand could not be cut on the wire EDM machines. Segments were created by cutting through the abrasive layer with a laser. Keep in mind that the lasers in the 70s and 80s were nothing like lasers of today either. The kerf and area damaged by the laser beam was close to 0.8mm and the lasers were only powerful enough to penetrate a little over 1mm in depth. After the laser cut the PCBN, the blanks were taken to a grinder, where a diamond-dicing wheel was used to cut through the carbide layer. Parts were then snapped apart for shipment to toolmakers. Today we have blanks routinely available greater than 58mm in diameter, in several different feeds in PCD, with many more compositions available in PCBN. Product technology has grown tremendously, and the machines used to create the tools have improved greatly as well. The generators on the wire and sinker EDMs of today use AC voltage and produce finishes that work very well in most final applications, they routinely cut at speeds greater than 11.0 inches per hour for a 3.2mm thick part. The design software using different Cad and 3D imaging make intricate geometries simple to create and load via DXF files into these machines. Many machine builders offer 4, 5 and even 6 axis control on their machines which enables the designers of today to not only control basic geometries, but also specify and create detailed edge preparations and relief angles on the finished tools. All of these improvements help optimize final machining results for the end user.



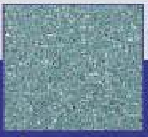
PCD AND PCBN APPLICATIONS AND COMPOSITIONS

There are many different compositions of both PCD and PCBN. Below, you will see typical recommended grades for various applications, along with illustrations of the material compositions.

PCD Grades

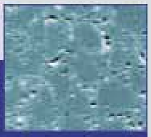


Average 4µm – PCDA, 90% vol. diamond



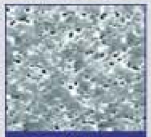
Average 5µm – PCDB, 92% vol. diamond

Average 25µm – PCDC, 94% vol. diamond

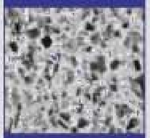


Average 25µm/ 4µm – PCDD, 95% vol. diamond

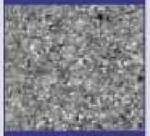
PCBN Grades



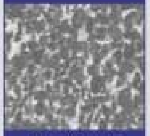
90% Volume CBN/Metal PCBN-A



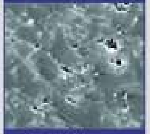
50% Volume CBN/TiN Based Matrix PCBN-B



90% Volume CBN/Ti Based Matrix PCBN-C



75% Volume CBN/Ti Based Matrix PCBN-D



82% Volume CBN/Ceramic Matrix PCBN-E

PCD Product Selection Chart

PCD		Grades
Fine Surface Finishes	Aluminum Copper Precious Metals Wood Composites Plastics	PCD-A
High Abrassive Resistance	<14%Si/AL Alloys Copper Alloys Graphite/Gr. Composites Wood Composites Green Ceramics Carbide	PCD-B
High Strength Interrupted/ Rough Cuts	.14% Si/AL Alloys Metal Matrix Composites Bi-Metals (aluminum/cast iron) Sintered Ceramics Carbides Highly Abrasive Material	PCD-C
Severe Applications	MMC Duralcan >15$ Si/AL Alloys Fiberglass Fiberboard Wood Laminates	PCD-D

PCBN Product Selection Chart

Pearlitic Gray Cast Iron	PCBN-A PCBN-E
Hard Cast Iron (>45 HRc)	PCBN-C PCBN-E
Hardened Steel Alloys (>45 HRc)	PCBN-B PCBN-C PCBN-E
Sintered Powder Metal Iron	PCBN-A PCBN-C PCBN-D PCBN-E
Superalloys	PCBN-A

PCD PROCESSING PITFALLS

Even with all of the improvements made in the machines used to process these materials, there are many variables that can negatively impact the final tool performance. Although wire EDM cutting speeds have improved greater than 10X over the earlier models, those of us producing parts would still like to see the parts cut faster.

1.) Too Aggressive Erosion

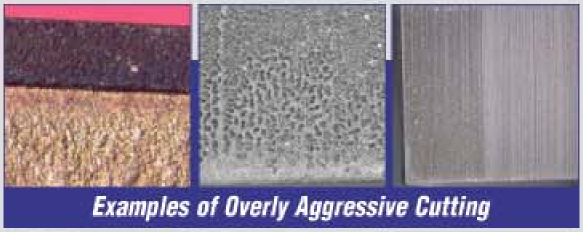
In the quest to achieve higher cutting rates, operators of these machines will increase the cutting voltages and amperages used to generate the erosion. Oftentimes this leads to disaster on the parts, requiring additional post processing. The carbide substrate and the PCD layer both react differently when exposed to the sparks. The diamond layer consists of diamond and a conductive material, normally some form of cobalt. This cobalt is a much softer material and erodes quicker than the diamond that surrounds it. Cutting parameters that are too aggressive tend to erode the cobalt, before actually cutting through the diamond leaving a porous surface with only the diamond crystals intact as illustrated below. These parameters also tend to create deeper erosion at the interface of the carbide and diamond surfaces.

2.) Improper Flushing

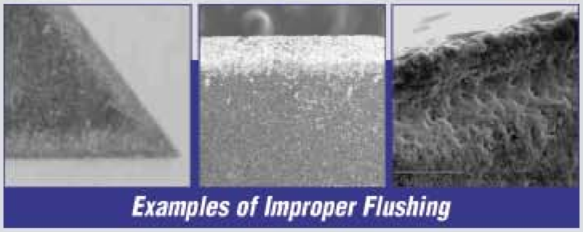
Another area that is often overlooked is the flushing of the cut area. Flushing is directed at the cut to remove materials that have been eroded and to cool the area surrounding the sparks. The flushing medium, or dielectric also serves to insulate the workpiece from the electrode. EDM machines use water or oil based materials as a dielectric, and may cut with the workpiece submerged, or with only localized flushing at the cut. In submerged applications, it is crucial that the conductivity of the dielectric be negligible. Many EDM operators will try to use their EDM machines to cut steel, aluminum and other materials when not cutting PCD. Although an EDM machine can cut these materials, it creates huge issues in the efficiency of the PCD cutting. These other materials leave microscopic residue in the machine, that when not removed allows for secondary current paths to exist. These secondary current paths lead to pitting and leaching of the cobalt on top of the PCD layer, as illustrated below in the light gray band bordering the cut edge. This band can have a width of 0.8mm with stray pitting further into the interior of the piece. Again, this will require extra finishing to remove this damaged area of the PCD. The picture on the right illustrates a situation where either the dielectric material is very conductive or acidic. This causes the entire upper surface to be non conductive and leads to the overhang shown. This edge is very weak and will crack or chip causing premature tool failure. One of the leading causes of acidic dielectric is the use of cleaners in the machine.

3.) Over Processing

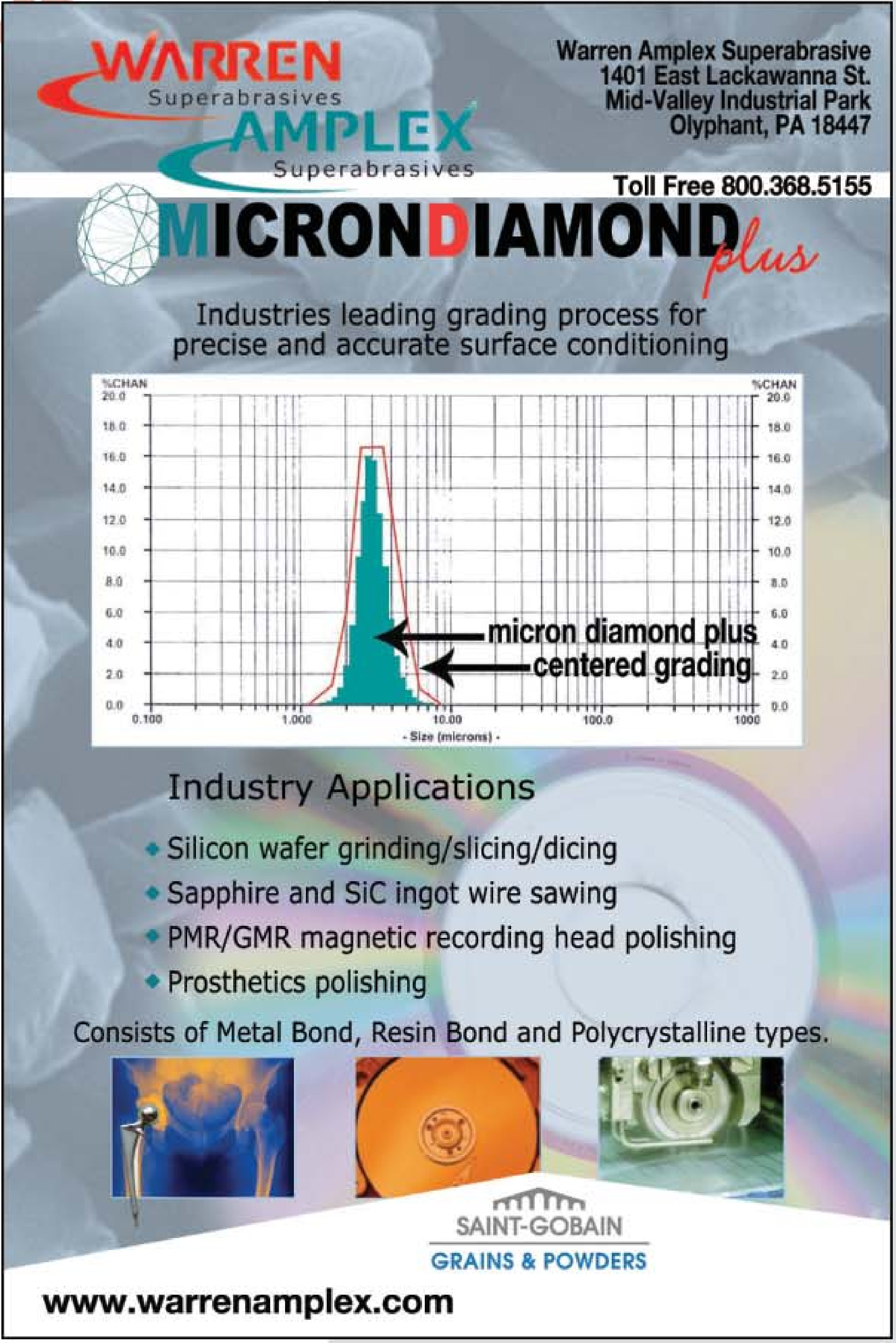
The third most common item is over processing of the finish edge. Most EDM machines are capable of rough cutting and numerous skim cuts. The old adage, "time is money" certainly applies in this situation. Skim cutting and good finishes are critical for optimizing an application; however, it is very important to know the application and what levels of finish are necessary. Approximately ten years ago, one of the manufacturers was bragging about the finish achieved on one equilateral triangle after one rough cut, and five skim cuts. Cutting this one triangle took almost 45 minutes, and the edge length was only 4.5mm. The part looked very nice but



Examples of Overly Aggressive Cutting



Examples of Improper Flushing



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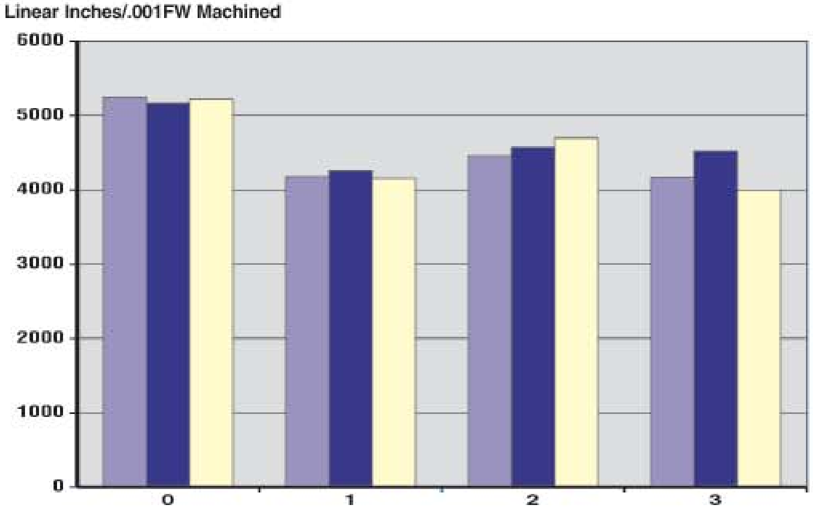
Ground versus WEDM Finish Inserts in A390 Cast Aluminum at 1500 sfm, .005 ipr, and .020" DOC



the time required to cut did not create any extra value in the final performance. The chart below may better illustrate the point of this discussion. Three EDM manufacturers cut parts that were used in machining tests of A390 cast aluminum. The speeds and feeds were controlled and the same for each grouping. The first group is standard tools with a ground finish. The second group is wire EDM cut with one skim cut, the third group two skim cuts, and fourth contains three skim cuts. In all cases, the height of the bar represents tool life. When looking at the EDM groups, it is clear that the group with the two skim cuts provides maximum tool life. If a manufacturer would elect to do three or more skim cuts for this particular application, additional processing costs would be incurred resulting in decreased tool life.

ACCEPTABLE FINISHES

An acceptable tool will have sharp edges and no chips that create stress points leading to premature failure. There will be minimal pitting so work piece material does not have the opportunity to adhere to the PCD surface, and minimal erosion at the PCD/ carbide interface.

PCD AND PCBN TOOLS INCREASE PERFORMANCE, REDUCE OPERATING COSTS

Although these products have been available since the mid 1970's, we continue to discover new and exciting applications for their use. The new applications continue to provide new sources of revenue for the tool manufacturer. Constantly improving machine technology allows for increasingly complex tool designs and improved finishing techniques. When used properly PCD and PCBN tools continue to provide increased performance, while greatly reducing operating costs for the end user.

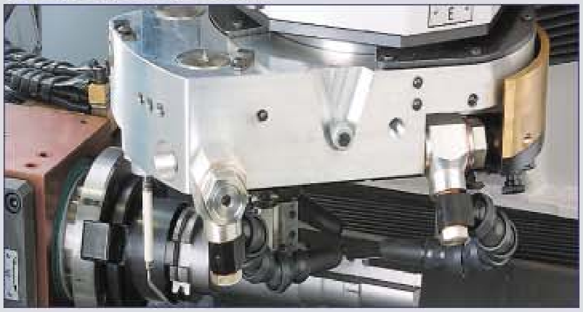
All case studies and application recommendations courtesy of Diamond Innovations and appear on their website www.abrasivesnet.com All photographs and machine illustrations courtesy of Vollmer of America and Diamond Innovations.

PCD BENEFITS – CASE STUDIES

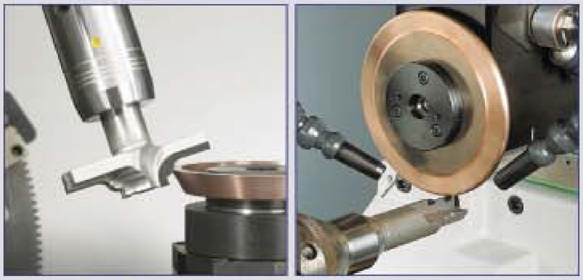
On page 23 are a few examples of case studies in comparison of carbide tools and show the real benefit of using PCD or PCBN materials in an application. Example one is a milling application using PCBN tools versus carbide creating molds for plastic soap bottles. Cycle time was reduced from 365 minutes to 75 minutes. Example two is face milling a fuel injection pump body. In this example a mid range PCD piece was used versus a standard carbide insert. Illustration of the tool design is below, and final results were PCD 402,500 pieces machined, carbide 19,500 pieces. The last example is a reaming application using PCD cutters in machining hydraulic cylinder bores. Final result - PCD machined 19,200 pieces, carbide machined 1,200 pieces.

FINISHING METHODS

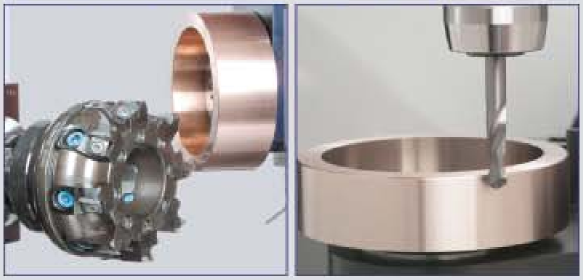
1.) Using Wire EDM to Finish



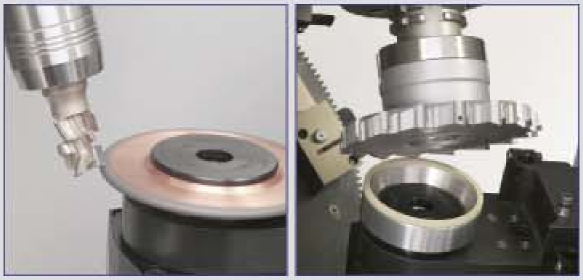
2.) Using Rotary Electrode with Peripheral Design to Finish



3.) Using a Rotary Electrode with a Face Design

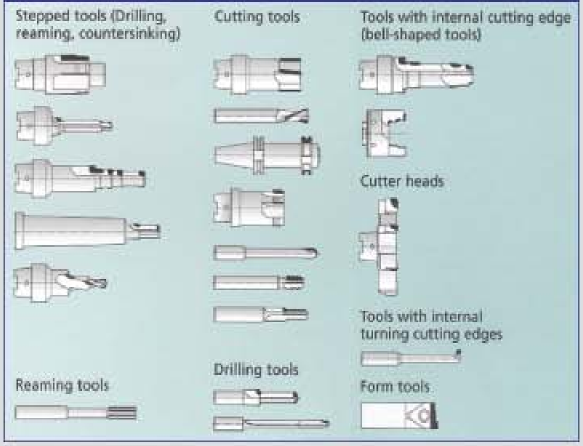


4.) Using Diamond Grinding Wheels



COMMON TOOL DESIGNS

Below are some of the tool designs with PCD/PCBN tips designated in black.


Stepped tools (Drilling, reaming, countersinking)
Cutting tools
Tools with internal cutting edge (bell-shaped tools)
Cutter heads
Tools with internal turning cutting edges
Drilling tools
Reaming tools
Form tools

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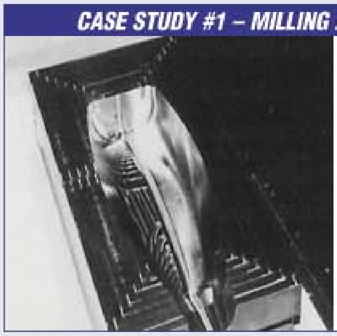
CASE STUDY #1 – MILLING APPLICATION USING PCBN TOOLS



Operation: High Speed of die in roughing and finishing.

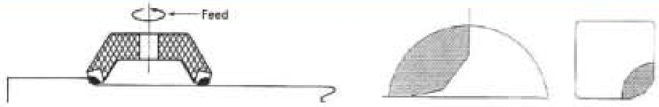
Industry: Tool & Die

Material: Die Steel – 5% Cr (Z38 CDV 5) HRc 38

Component: Die for plastic soap bottle – volume 880 cc.

Machine:	5 axis Milling machine / Alcera Gambin 120C High Speed Spindle – Fischer FEX 100 (20kw/18000 rpm)	
Tool Data:	Roughing Mill – 25 mm D / 2 tooth indexable 12mm insert Finishing: ball nose end mill – 20 mm diameter	
Product:	PCBN 90 vol% cBN/Meter 2μm	
Process Parameters:	**Roughing**	**Finishing**
Cutting Speed	500 m/min	820 m/min
Feed Rate	1600 mm/min	2600 mm/min
Depth of Cut	1/3 mm	0.8 - 1/5 mm
Coolant	Refrigerated compressed air	
RESULTS: **Cycle Time**	75 minute	
Tool Life	Roughing – 1 indexed edge per mold, 4-5 indexes/ insert, Finishing – 3+ molds	
Surface Finish	Visual condition was excellent	

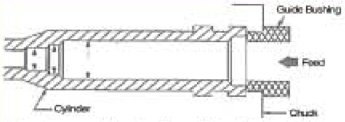
CASE STUDY #2 – PCD Inserts vs. Carbide Inserts



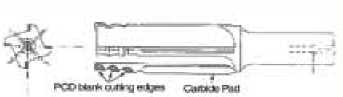
First image is a cross-sectional view of a face mill made with PCD inserts. Radial rake angle is +2°, 30 min.; axial rake angle is +5°; true rake angle is +4°, 24 min. Second image is PCD insert for face mill made by brazing a precut PCD material into a pocket in a carbide pocket. Cutting edges are ground to correct final geometry.

	PCD	Carbide Insert
Workpiece	Fuel injection pump body	
Material	Diecast aluminum (5-7% Si, HRB 90)	
Type of Tool	Face mill (8 inserts)	
Tool Diameter, in. (mm)	5 (127)	
Machining Conditions		
Surface speed, ft./min. (m/min)	2237 (682)	
Depth of cut/pass, in. (mm)	0.200 (5)	
Feed, in./min. (mm/min)	27.6 (690)	
Feed per revolution, in. (mm)	0.160 (4)	
Feed/cutting edge/revolution, in. (mm)	0.020 (0.5)	
Cutting fluid	Soluble oil (15:1 - 20:1 concentration)	
RESULTS Cutting edge life, pieces	402,500 (no regrinding)	2375 (new insert) 5000 (reground insert)
Insert life, pieces	402,500	19,500 (based on using four corners plus regrinding two corners)
Surface finish, μin., Ra (μm, Ra)	16-32 (0.4-0.8)	18-48 (0.45-1.2)
Economics		
Initial insert cost, 402,500 pcs., $	677.97	573.72
Insert regrinding cost, $	Not Required	104.03
Insert tool cost, $	5.93 (one setup)	734.65 (124 setups)
Total tool cost, $	683.90	1,412.40
Total tool cost/piece, $	0.002	0.004
Savings, $ (%)	728.50 (52)	–

CASE STUDY #3 – Polycrystalline Diamond Step Reamers vs. Carbide Step Reamers



Three bores in hydraulic cylinder (indicated by arrows) are brought to final size and finish in one operation by a step-type reamer made with polycrystalline diamond. Drawing not to scale.



PCD blank step reamer. The blanks are brazed to the steel tool shank, then ground to the required final geometry and finish. Four blanks are used for each step in the tool.

	PCD	Carbide Reamer
Workpiece	Power steering hydraulic cylinder	
Material	Diecast aluminum (ASTM SC102A)	
Type of Tool	Step type reamer	
Machining Conditions		
Surface speed, ft./min. (m/min)	234.8 (71.6)	
Feed per revolution, in. (mm)	0.010 (0.25)	
Cutting fluid	Soluble oil	
RESULTS		
Edge life before regrinding, pieces	9600	200
Number of regrinds	1	5
Total tool life, pieces	19,200	12,000
Surface finish, μin., Ra (μm, Ra)	24-32 (0.6-0.8)	48-80 (1.2-2.0)
Economics		
Initial tool cost, $	1,250.00	$292.37
Regrinding cost, $	63.56 (1 regrind)	48.73 (5 regrinds)
Total tool cost, $	1,313.56	0.28
Total tool cost for 19,200 pieces, %	0.06	0.004
Savings, $ (%)	4,144.04 (76)	–

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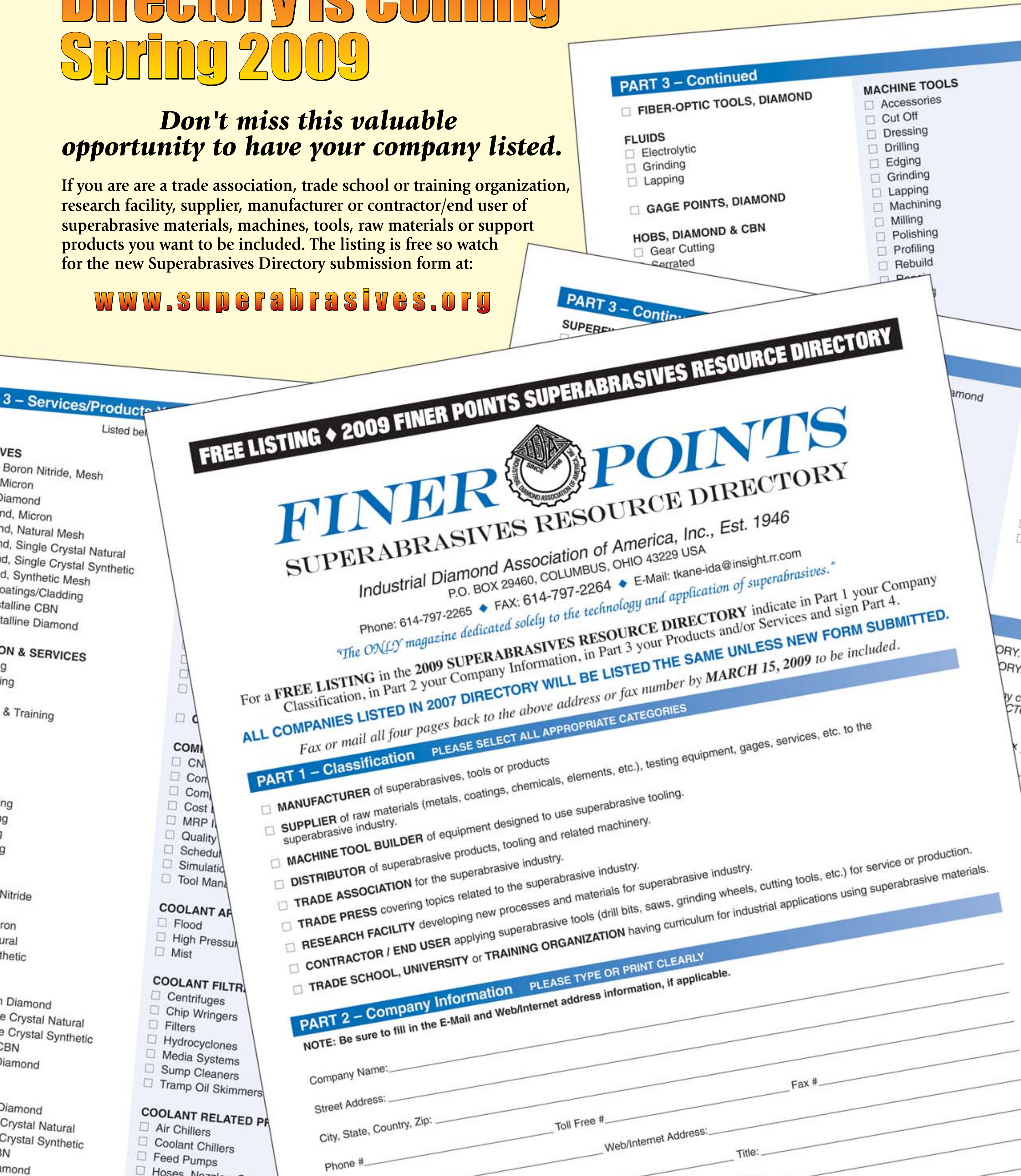

PART 3 – Continued

☐ FIBER-OPTIC TOOLS, DIAMOND

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☐ Electrolytic
☐ Grinding
☐ Lapping

☐ GAGE POINTS, DIAMOND

HOBS, DIAMOND & CBN
☐ Gear Cutting
☐ Serrated

MACHINE TOOLS
☐ Accessories
☐ Cut Off
☐ Dressing
☐ Drilling
☐ Edging
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☐ Rebuild

PART 3 – Contin

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nd, Single Crystal Synthetic
d, Synthetic Mesh
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talline CBN
talline Diamond

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e Crystal Natural
e Crystal Synthetic
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Crystal Natural
Crystal Synthetic

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*Fax or mail all four pages back to the above address or fax number by **MARCH 15, 2009** to be included.*

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☐ **SUPPLIER** of raw materials (metals, coatings, chemicals, elements, etc.), testing equipment, gages, services, etc. to the superabrasive industry.
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☐ **TRADE PRESS** covering topics related to the superabrasive industry.
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☐ **CONTRACTOR / END USER** applying superabrasive tools (drill bits, saws, grinding wheels, cutting tools, etc.) for service or production.
☐ **TRADE SCHOOL, UNIVERSITY** or **TRAINING ORGANIZATION** having curriculum for industrial applications using superabrasive materials.

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Phone #: Web/Internet Address: Title:

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Shipping Address (Can not ship to PO Box) ______________________________
City ______________________ State ______ Zip Code/Postal Code ____________ Country ______________
Phone ______________________________ Fax ______________________________
E-mail ______________________________ Web Site ______________________________
Official Representative ______________________________
Others (Participating in IDA Activities) ______________________________
Principle Business Activity ______________________________
Which applies to your company: ______ Corporation ______ Partnership ______ Sole Proprietorship
Provide names of principle officers or partners: ______________________________
When was your company established? ____________
How long has your company been engaged in superabrasive/ultra-hard material industry? ________
List at least two business references, preferably one is an IDA member (name, company and address of each):
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2. ______________________________

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Any company and/or individual classified as a superabrasive/ultra-hard material supplier, tool maker, machine tool builder, end user or related business with offices in the USA, Canada or Mexico is eligible in this category. Only one individual shall be designated by each member company as the IDA Delegate with voting and other privileges described in the By-Laws.

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Check to appropriate category:

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_____	Category 3	$1,709 per year	$6,000,000 - $9,999,999 Annual Sales
_____	Category 4	$1,328 per year	Under $2,000,000 - $5,999,999 Annual Sales
_____	Category 5	$975 per year	Under $1,999,999 Annual Sales

Name of Delegate Voting Member: ______________________________
Title: ____________________ E-Mail: ______________________

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Planned issues, topics and closing dates:

Issue:	**Editorial Feature*:**	**Closing**
Winter 2008/2009	Polycrystalline cBN & Diamond	Nov. 30, 2008
Spring 2009	Superabrasives Resource Directory	Mar. 31, 2009
Summer 2009	New Superabrasive Applications & Products	May 31, 2009
Fall 2009	CVD Diamond	Aug. 31, 2009
Winter 2009/2010	INTERTECH 2010 Preview	Nov. 30, 2009
Spring 2010	INTERTECH Preview	Mar. 31, 2009

***Editorial topics subject to change**

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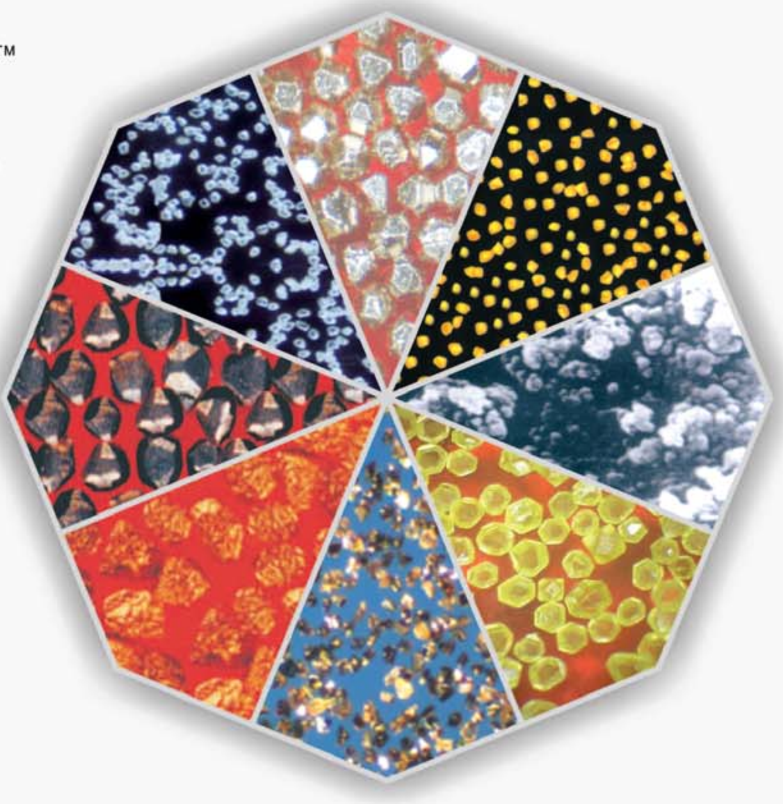

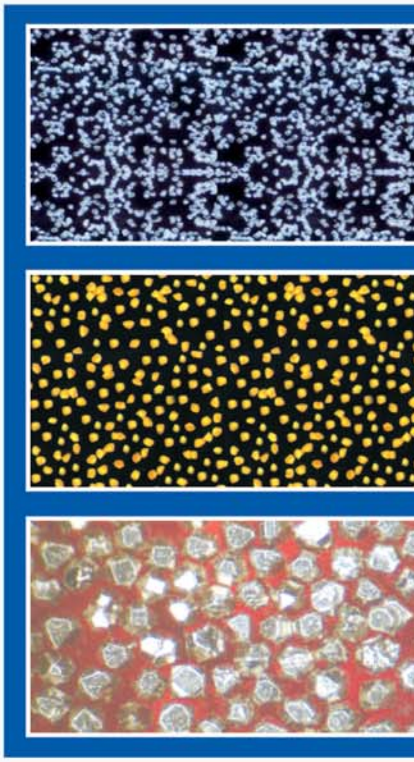

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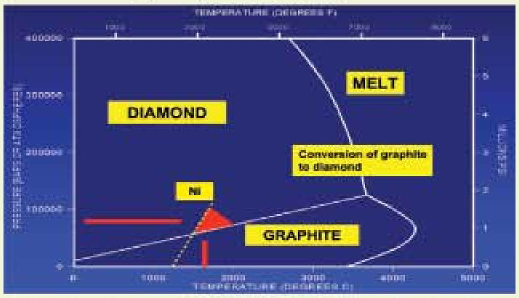
PCD Engineered for the Demands of High-Speed Milling

By: Jeremy W. Peterson, P.R. Davis, MegaDiamond Inc.
& H. Hack, Hollfelder-Gühring GmbH.

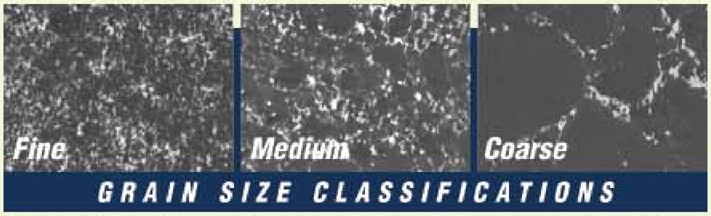
High-speed milling practices are becoming more prevalent in today's manufacturing industry. Although PCD material technology in general is reaching maturity, the demands of high-speed milling impart a challenge for improvements from PCD suppliers. Medium grain size PCD materials are generally used for their ability to strike a balance between good abrasion resistance (tool life) and maintaining good workpiece surface finish. Typical failure mode for milling inserts is loss of cutting edge sharpness resulting in burr formation on the workpiece. The challenge is to minimize this burr formation while improving surface finish. Specific material properties such as flexural strength and toughness can be improved through an engineered diamond grain size distribution and advanced processing techniques to accomplish this. The result is a PCD material with improved cutting edge retention, better work-piece surface finish without sacrificing wear resistance; thus, delivering ultimate performance gains in high-speed milling applications.

PCD MANUFACTURING



PCD is a composite material manufactured by sintering together a mass of diamond grains under ultra-high pressure and high temperature (HP/HT) conditions. At the same time that the PCD layer is fused together it is integrally bonded to a tungsten carbide substrate. The sintering of diamond particles relies on diffusion of cobalt metal, in this case coming from the carbide substrate, to facilitate diamond grain growth between crystals, forming strong diamond-to-diamond bonding. The residual pore spaces between the diamond crystals are filled with Co metal, forming metallic pools throughout the diamond matrix. The resultant product combines the extreme hardness, high thermal conductivity, and abrasion resistance of diamond with the toughness properties approaching that of tungsten carbide.

TRADITIONAL PCD GRADE CLASSIFICATIONS



GRAIN SIZE CLASSIFICATIONS

PCD products for the metal cutting industry have traditionally been classified into four general categories. The main controlling factor determining PCD grade is the relative diamond particle size. Consequently, we use this relative grain size as a reference to categorize Extra Fine, Fine, Medium and Coarse grade PCD products. It is generally accepted that abrasion resistance increases with increased grain size. While simply increasing the grain size does provide better abrasive wear resistance, several other desirable properties such as tool edge quality, edge toughness, and work piece surface finish are diminished.

A NEW APPROACH TO HIGH-SPEED MILLING

The milling and turning of automotive materials such as Al-Si alloys typically require a medium grade PCD for an optimum combination of tool life and component surface finish. However, as current working practices demand increasingly faster machining operations, current tool performance has been reduced due to the loss of cutting edge sharpness resulting in burr formation on the work piece. To overcome this some tool manufactures have attempted to introduce coarse grade PCD to maintain an acceptable tool life. Unfortunately, the increase in grain size has lead to reduced surface finish on the component, typically deemed unacceptable in providing satisfactory performance in these more aggressive applications. In response to this increased demand on medium grade PCD cutting tool products our company has developed a new, technically advanced type of medium grade PCD. Using a select blend of diamond particles coupled with proprietary methods of powder preparation and the addition of toughening agents, the durability of diamond is substantially increased. These techniques, in combination with a unique sintering technology, produces a material with dramatically improved diamond-to-diamond bonding and a more uniform polycrystalline microstructure. This advanced PCD structure not only improves wear resistance, but also enhances other essential cutting tool properties such as wire-EDM cuttability, edge quality and edge toughness.

A MATERIALS ENGINEERING APPROACH

In order to produce a material that exhibits improved edge toughness combined with similar if not improved wear resistance, several modifications to the polycrystalline microstructure were necessary. This is achieved by two approaches. First the feedstock diamond powders are carefully selected and blended. The largest grains, which provide the superior abrasion resistance, yet detract from the edge quality of the tool, were removed resulting in an overall reduction of average grain size of the material. Secondly, a new process of powder preparation increases the packing density and surface activity of the diamond grains prior to sintering. This facilitates and maximizes diamond-to-diamond bonding of the diamond grains; the resulting polycrystalline microstructure exhibits minimized interstitial gaps compared to traditional medium grade PCD products. The metallic second phase provides a toughening effect, but must be dispersed evenly to provide uniform and consistent properties. If excessive interstitial metallic pools or gaps exist between diamond crystals, a weakness becomes inherent by degrading desired properties of the cutting tool such as, abrasion resistance, chemical and thermal stability.

This unique and proprietary manufacturing process has brought about significant breakthroughs in the ability to provide a highly dense structure of diamond crystals adjacent to other diamond crystals. These diamond crystals are closely packed maximizing the surface contact between each other through this patented high shear compaction (HSC) technology. This enables superior material transfer between diamond crystals during the sintering process, minimizing the amount of metal pools that form. The result is a uniform and evenly dispersed metal diffusion allowing a high degree of bonding between diamond crystals, providing both superior abrasion resistance and edge toughness. This also enhances thermal and chemical properties of the cutting tool, which are also key to overall performance.

To illustrate the degree of improvement in the PCD microstructure and the uniform dispersion of the metallic second phase, side-by-side micrographs of typical medium grade PCD and AMX grade PCD structures are provided (figure 1-2). As previously discussed, the target is to achieve a uniform microstructure, with smaller and better-dispersed metallic pools. This results in a minimized but desired level of second phase and optimized diamond-to-diamond bonding.

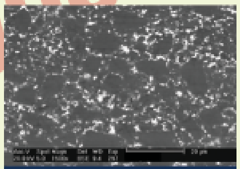


Fig. 1 – Typical Medium Grade PCD 1500X

The general failure mode of medium grade PCD in typical abrasive, non-ferrous metal cutting and milling applications is a dulling or breakdown of the cutting edge through attrition. This means the boundaries between two adjacent diamond particles, normally filled with a second phase binder material are weakened during the cutting application, eventually causing diamond grain pull-out leading to edge chipping and burr formation on the component. By employing the use of this new manufacturing method, the inter-granular bonding is greatly increased, effectively minimizing these defined grain boundaries that become weakened during the cutting application. Result is more effective edge retention of the PCD cutting tool, which translates into substantial improvements in tool life.

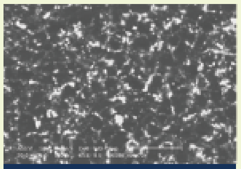
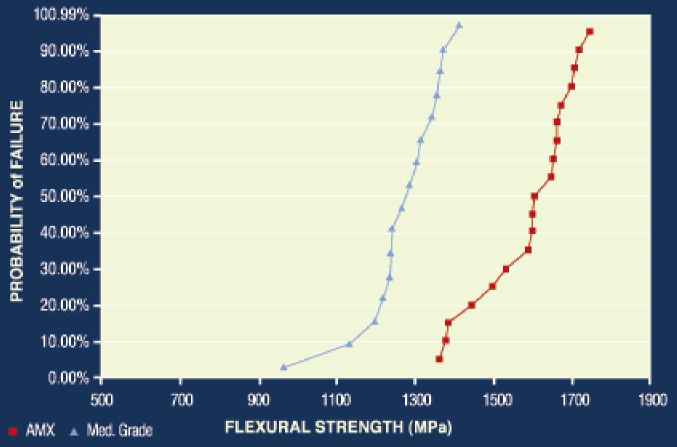


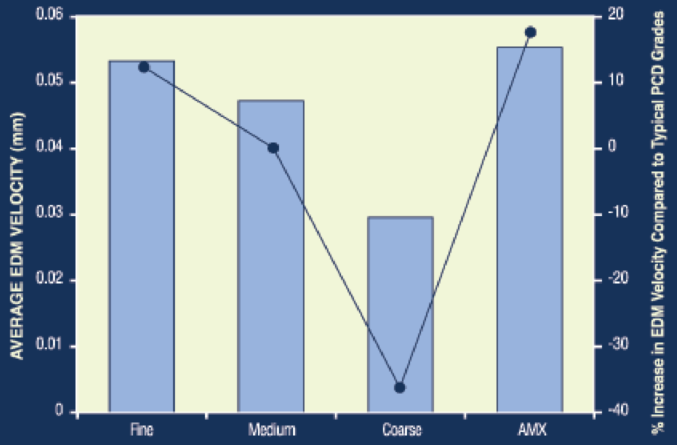
Fig. 2 – Illustrates Effect of Applying the HSC Technology. Note more uniform particle size distribution & improved inter-granular bonding.

TRS values of typical medium grain PCD and AMX grade PCD (shown in figure 3). It is evident that the flexural strength of the material has been significantly increased, which leads to reduced incidence of tool edge chipping in application. The optimal life of the tool is thereby extended.



Above Figure 3

Below Figure 4



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BENEFITS

Today all medium grades of PCD are typically cut with wire-EDM with varying degrees of success. Cuttability by wire-EDM is a function of how uniformly the conductive metallic phase is dispersed throughout the diamond matrix. Controlled cutting tests show that the AMX grade cuts more efficiently than other medium grade products. AMX has shown an increase in EDM cuttability of up to 15 percent over typical medium grade PCD (figure 4).

As previously discussed, the quality of the ground edge that can be produced using typical medium grade PCD products is crucial for achieving an optimum tool life performance and work piece surface finish. By tailoring the diamond particle distribution and improving the packing density of the diamond grains, it has been shown that the edge quality achievable with AMX is notably improved compared with traditional medium grade PCD. The magnified edge of finish-ground PCD inserts, one fabricated with grade AMX and the other with a competitive medium grade show a distinct improvement in edge sharpness using AMX grade (figures 5-6). Likewise figures 7 & 8 show highly magnified edge of a rotary tool finished with a wire EDM, one fabricated with AMX and the other with a competitive medium grade PCD.

Controlled field test applications have indicated up to a 100% increase in tool life in high-speed automotive machining applications. Two examples are provided in table.

FIRST MILLING EXAMPLE

Component:	10% Si-Al road car cylinder head	
Operation:	Milling	
Diameter:	315mm	
No of teeth:	28	
Speed:	2000 m/min	
Feed per tooth:	0.07mm/tooth	
Depth of cut:	0.5 mm	
Results	AMX:	12000 components
	Competitive medium grade:	5000 components

SECOND MILLING EXAMPLE

Component:	7-9% Si-Al V6 sports car cylinder head	
Operation:	Milling	
Diameter:	200 mm	
No. of teeth	20	
Speed:	3800 m/min at 6000 RPM (Competitive medium grade ran at 2500 m/min)	
Advance:	12000 mm/min	
Feed per tooth:	0.1 mm/tooth	
Depth of cut:	0. 5mm	
Results	AMX:	2000 parts per edge
	Competitive medium grade:	1300 parts per edge

AMX reduced burr compared to competitive medium grade due to better tool edge quality.

Additional independent field tests have been carried out in aluminum wheel turning and engine block milling applications, which have shown performance increases of up to 3 times compared to typical medium grade PCD grades.

Through blending of diamond powders of tightly controlled particle size distributions and the use of propriety powder preparation techniques which maximize diamond packing density, it has been possible to produce a material with superior physical and mechanical properties compared to standard medium grade PCD. The result is a new generation medium grade PCD that not only provided superior wear resistance, but also provides better tool edge quality, edge toughness, and fabrication properties. ■

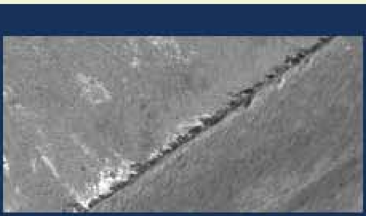

Fig. 5 – Typical Ground Edge, AMX 500X

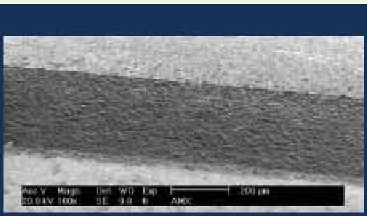

Fig. 7 – Typical EDM Edge AMX

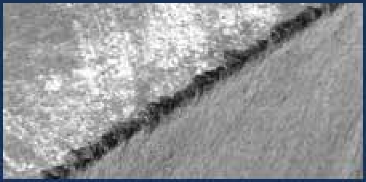

Fig. 6 – Typical Ground Edge, Medium Grain PCD Grade 500X

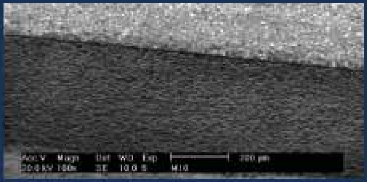

Fig. 8 – Typical EDM Edge, Medium Grain PCD

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☐ Visit the IDA Website at: www.superabrasives.org and submit a question or comment.

☐ Contact an IDA member for products or services.

☐ Mark my calendar to attend IDA Annual Meeting, March 11-13, 2009 in Longboat Key, Florida.

☐ Mark my calendar to attend Intertech 2010, March 15-17, 2010 in Lake Las Vegas, Nevada.

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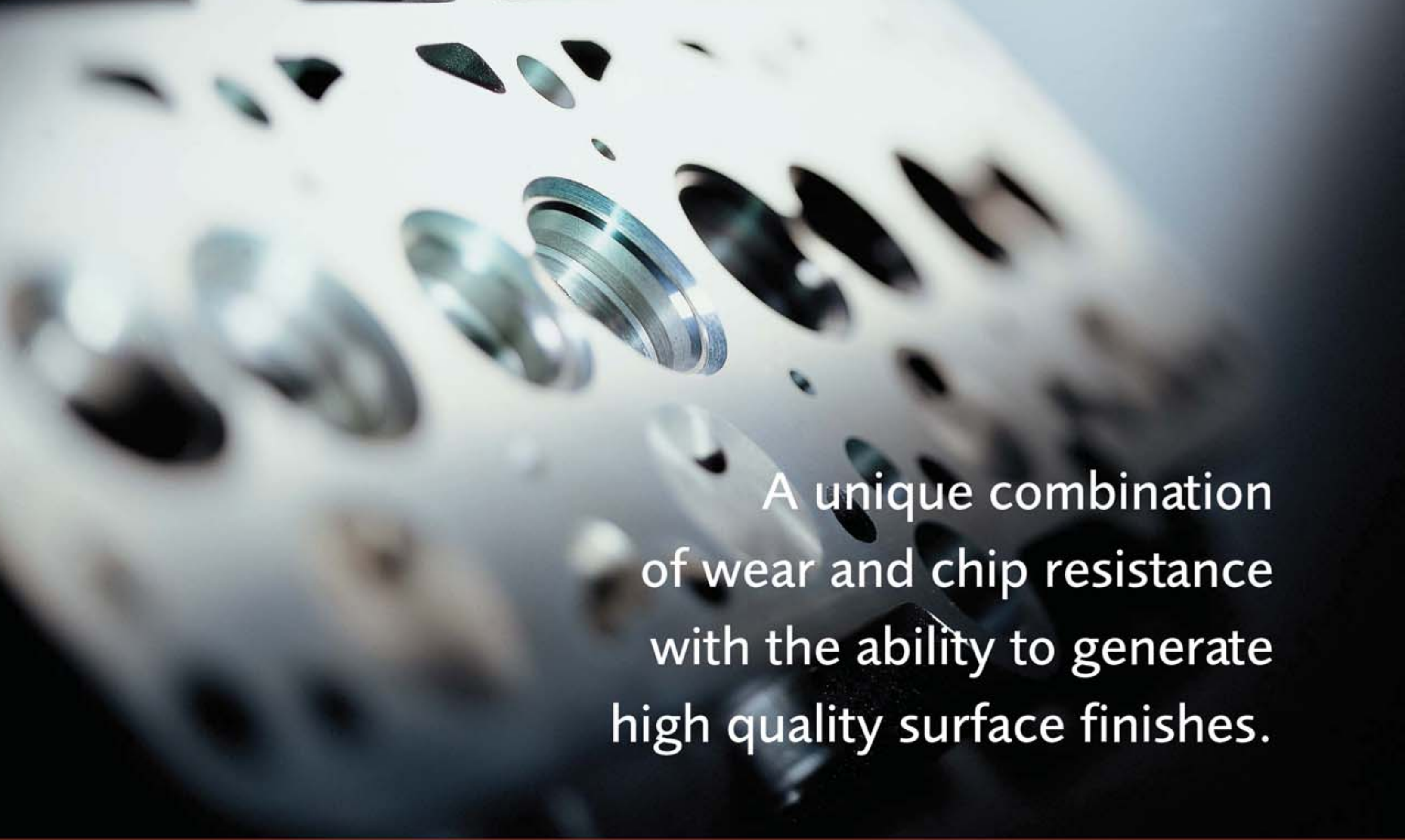
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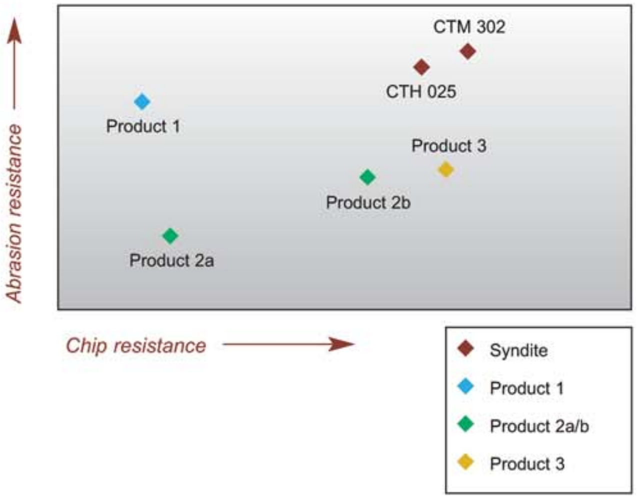

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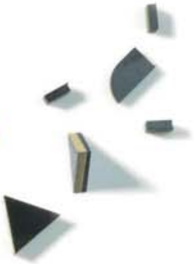

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